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APPLICATION NUMBER: ***60/555,253***
FILING DATE: ***March 22, 2004***
RELATED PCT APPLICATION NUMBER: ***PCT/US05/09621***

UNITED STATES PATENT AND TRADEMARK OFFICE
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

Express Mail Label No. EL 912754419 US

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
MARK FRANCIS	RUMREICH	INDIANAPOLIS IN US

☐ *Additional inventors are being named on the _____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

APPARATUS AND METHOD FOR SMOOTH PIXEL DIGITAL LIGHT PROCESSING

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages* 6
☐ CD(s), Number ____
☒ Drawing(s) *Number of Sheets* 4
☐ Other (specify) ____
☐ Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☐ Applicant claims small entity status. See 37 CFR 1.27.
☐ A check or money order is enclosed to cover the filing fees
☒ The Director is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 07-0832
☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE AMOUNT ($): $160

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.
☐ Yes, the name of the U.S. Government agency and the Governm contract number are: _____.

Respectfully submitted,
SIGNATURE [signature]
Date March 22, 2004

TYPED or PRINTED NAME CHRISTINEJOHNSON
REGISTRATION NO 38507
Docket Number: PU040040

TELEPHONE 1 609 734 6892

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

FEE TRANSMITTAL for FY 2004

Effective 10/01/2003. Patent fees are subject to annual revision.

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 160

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	MARK FRANCIS RUMREICH
Examiner Name	
Art Unit	
Attorney Docket No.	PU040040

METHOD OF PAYMENT (*check all that apply*)

☐ Check ☐ Credit card ☐ Money Order ☐ Other ☐ None

☒ Deposit Account:

Deposit Account Number	07-0832
Deposit Account Name	THOMSON LICENSING INC.

The Director is authorized to: (*check all that apply*)
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FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1001	770	2001	385	Utility filing fee	
1002	340	2002	170	Design filing fee	
1003	530	2003	265	Plant filing fee	
1004	770	2004	385	Reissue filing fee	
1005	160	2005	80	Provisional filling fee	160

SUBTOTAL (1) ($) 160

2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE

			Extra Claims		Fee from below		Fee Paid
Total Claims	-	** =	0	X		=	0
Independent Claims	-	** =	0	X		=	0
Multiple Dependent				X		=	0

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
1202	18	2202	9	Claims in excess of 20
1201	86	2201	43	Independent claims in excess of 3
1203	290	2203	145	Multiple dependent claim, if not paid
1204	86	2204	43	** Reissue independent claims over original patent
1205	18	2205	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 0

***or number previously paid, if greater; For Reissues, see above*

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1051	130	2051	65	Surcharge - late filing fee or oath	
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet.	
1053	130	1053	130	Non-English specification	
1812	2,520	1812	2,520	For filing a request for reexamination	
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	420	2252	210	Extension for reply within second month	
1253	950	2253	475	Extension for reply within third month	
1254	1,480	2254	740	Extension for reply within fourth month	
1255	2,010	2255	1,005	Extension for reply within fifth month	
1401	330	2401	165	Notice of Appeal	
1402	330	2402	165	Filing a brief in support of an appeal	
1403	290	2403	145	Request for oral hearing	
1451	1,510	1451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive – unavoidable	
1453	1,330	2453	665	Petition to revive – unintentional	
1501	1,330	2501	665	Utility issue fee (or reissue)	
1502	480	2502	240	Design issue fee	
1503	640	2503	320	Plant issue fee	
1460	130	1460	130	Petitions to the Commissioner	
1807	50	1807	50	Processing fee under 37 CFR 1.17 (q)	
1806	180	1806	180	Submission of Information Disclosure Stmt	
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	
1809	770	2809	385	Filing a submission after final rejection (37 CFR § 1.129(a))	
1810	770	2810	385	For each additional invention to be examined (37 CFR § 1.129(b))	
1801	770	2801	385	Request for Continued Examination (RCE)	
1802	900	1802	900	Request for expedited examination of a design application	

Other fee (specify) _____

*Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 0

SUBMITTED BY

Complete (*if applicable*)

Name (Print/Type)	CHRISTINE JOHNSON	*Registration No. (Attorney/Agent)*	38507	*Telephone*	1 609 734 6892
Signature	[signature]			*Date* 3/22/04	March 22, 2004

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APPARATUS AND METHOD FOR SMOOTH PIXEL DIGITAL LIGHT PROCESSING

Field of the Invention

[0001] The present invention generally relates to a filter to pre-correct video prior to "smooth pixel DLP" processing.

Background of the Invention

[0002] Smooth pixel Digital Light Processing (DLP) "contaminates" each pixel with the upper, lower, left & right adjacent input pixels, thereby blurring the image in some cases. Pre-correction filters for other applications are traditionally either the cascade of vertical and horizontal filters, or involve diagonal coefficients. These filters involve "noncontaminating pixels" and therefore, in some cases, do not adequately correct the problem. One proposed approach to Digital Light Processing (DLP) is referred to as "Smooth pixel DLP". In this approach, rather than using traditional square pixels oriented horizontally and vertically, square pixels are rotated 45 degrees. The rotated pixels are referred to as "diamond pixels" (see figure 1).

[0003] According to a proposed technique, in addition to using diamond pixels, smooth pixel DLP modulates the angle of a mirror in the image light path in order to increase the effective resolution. By changing the angle of the mirror, the diamond pixels are shifted downward by half a pixel, resulting in a secondary set of pixels centered on the interstices of the primary set of pixels (see figure 2).

[0004] The modulation produces both primary and secondary pixel sets for each incoming picture, effectively doubling the number of pixels. But because of the overlap between pixel sets, there is a loss of apparent resolution (as compared to having the combined number of pixels in a non-overlapping arrangement). In other words, each combined pixel is "contaminated" by the four adjacent pixels of the other pixel set. Accordingly, devices and methods for canceling the contamination effect are needed.

Summary of the Invention

[0005] The present invention is an apparatus and method for pre-correcting video to reduce the contamination effect caused by smooth pixel DLP modulation.

Brief Description of the Drawings

Preferred embodiments of the present invention will be described below in more detail, with reference to the accompanying drawings, in which:

Figure 1 is an illustration of a "diamond pixel" of the prior art.

Figure 2A is an illustration of a primary pixel set.

Figure 2B is an illustration of a secondary pixel set.

Figure 2C is an illustration of a combined pixel set.

Figure 3A is an illustration of a primary pixel set.

Figure 3B is an illustration of a primary pixel set.

Figure 3C is an illustration of a combined pixel set.

Figure 4 is a diagram of a filter according to an embodiment of the invention.

Detailed Description

[0006] "Smooth pixel DLP" is a term used to refer to Texas Instruments approach to a form of Digital Light Processing. Instead of using traditional square pixels oriented horizontally and vertically, square pixels are rotated 45 degrees. These are referred to as "diamond pixels" (see figure 1).

[0007] In addition to using diamond pixels, one approach to smooth pixel DLP modulates the angle of a mirror in the image light path in order to increase the effective resolution. By changing the angle of the mirror, the diamond pixels are shifted downward by half a pixel, resulting in a secondary set of pixels centered on the interstices of the primary set of pixels (see figure 2).

[0008] The modulation produces both primary (Figure 2A) and secondary (Figure 2B) pixel sets for each incoming picture. This effectively doubles the number of pixels. But because of the overlap between pixel sets, there is a loss of apparent resolution (as

compared to having the combined number of pixels in a non-overlapping arrangement) (Figure 3B). In other words, each combined pixel (Figure B) is contaminated by the four adjacent pixels of the other pixel set. The invention is a system and method of substantially canceling this effect.

[0009] According to an embodiment of the invention, each incoming pixel data point directly corresponds to one pixel on the combined pixel grid. For example, in an illustrative embodiment of the invention, the incoming pixel data for one component (in one embodiment YUV, in an alternative embodiment RGB) is as follows:

A	B	C	D	E
F	G	H	I	J
K	L	M	N	O

[0010] Figures 3A, 3B and 3C show how the above input samples are mapped to the smooth pixels. Referring to figure 3, each input pixel is "contaminated" by the four adjacent pixels of the other pixel set. For example, the H pixel is contaminated by the C, G, I and M pixels. In other words, each pixel is contaminated by the upper, lower, left and right adjacent pixels in the incoming pixel data. By using a pre-correction filter of the present invention on the incoming pixel data, it's possible to offset the degradation due to this contamination effect.

[0011] In one embodiment of the invention, a two-dimensional precorrection filter configured as follows is employed:

$$\begin{array}{ccc} & \alpha & \\ \alpha & \beta & \alpha \\ & \alpha & \end{array}$$

[0012] In one embodiment of the invention, alpha is -1/8. This provides provide unity DC gain and optimum pre-correction. In an embodiment of the invention, Beta is 1 - 4*alpha for unity DC gain. In one embodiment of the invention, for alpha = -1/8, beta is 3/2. In effect, the filter of an embodiment of the invention subtracts out contaminating

pixel information from each input pixel. By processing the input pixel data with this filter, pre-corrected input pixel data is provided. The pre-corrected pixel data is then processed by smooth pixel processing.

$$\begin{matrix} A & B & C & D & E \\ F & G & H & I & J \\ K & L & M & N & O \end{matrix} \quad \rightarrow \quad \begin{matrix} A' & B' & C' & D' & E' \\ F' & G' & H' & I' & J' \\ K' & L' & M' & N' & O' \end{matrix}$$

[0013] Figure 4 illustrates a filter in accordance with an embodiment of the invention. In this embodiment, eight levels of pre-correction are provided, from alpha = 0 to alpha = -7/32, in 1/32 steps.

[0014] While foregoing is directed to the preferred embodiment of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

Claims

1. A method for filtering pixel data comprising the steps of:

applying a pre-correction filter to said pixel data to provide pre-corrected pixel data;

smooth pixel processing said pre-corrected pixel data.

Abstract of the Disclosure

A method and apparatus are disclosed for filtering pixel data. The method comprises the steps of applying a pre-correction filter to the pixel data to provide pre-corrected pixel data. The pre-corrected pixel data is subjected to smooth pixel processing.

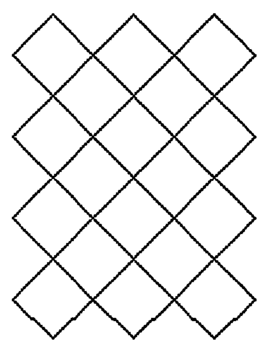


Figure 1

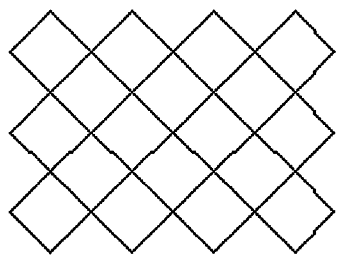

Primary pixel set

Figure 2A

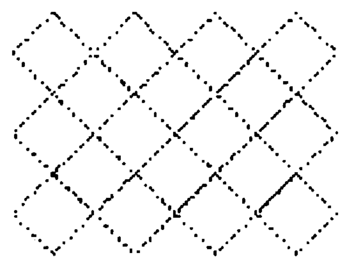

Secondary pixel set

Figure 2B

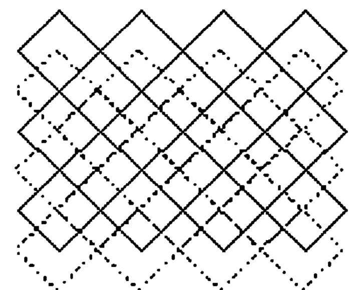
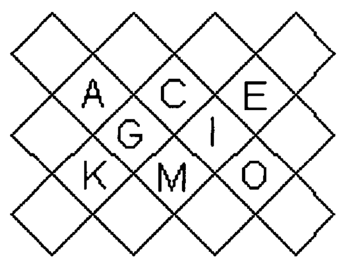
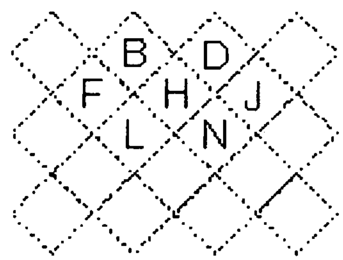

Combined pixel set

Figure 2C



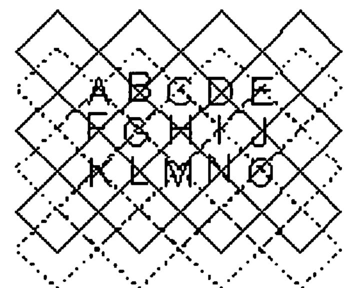
Primary pixel set

Figure 3A



Secondary pixel set

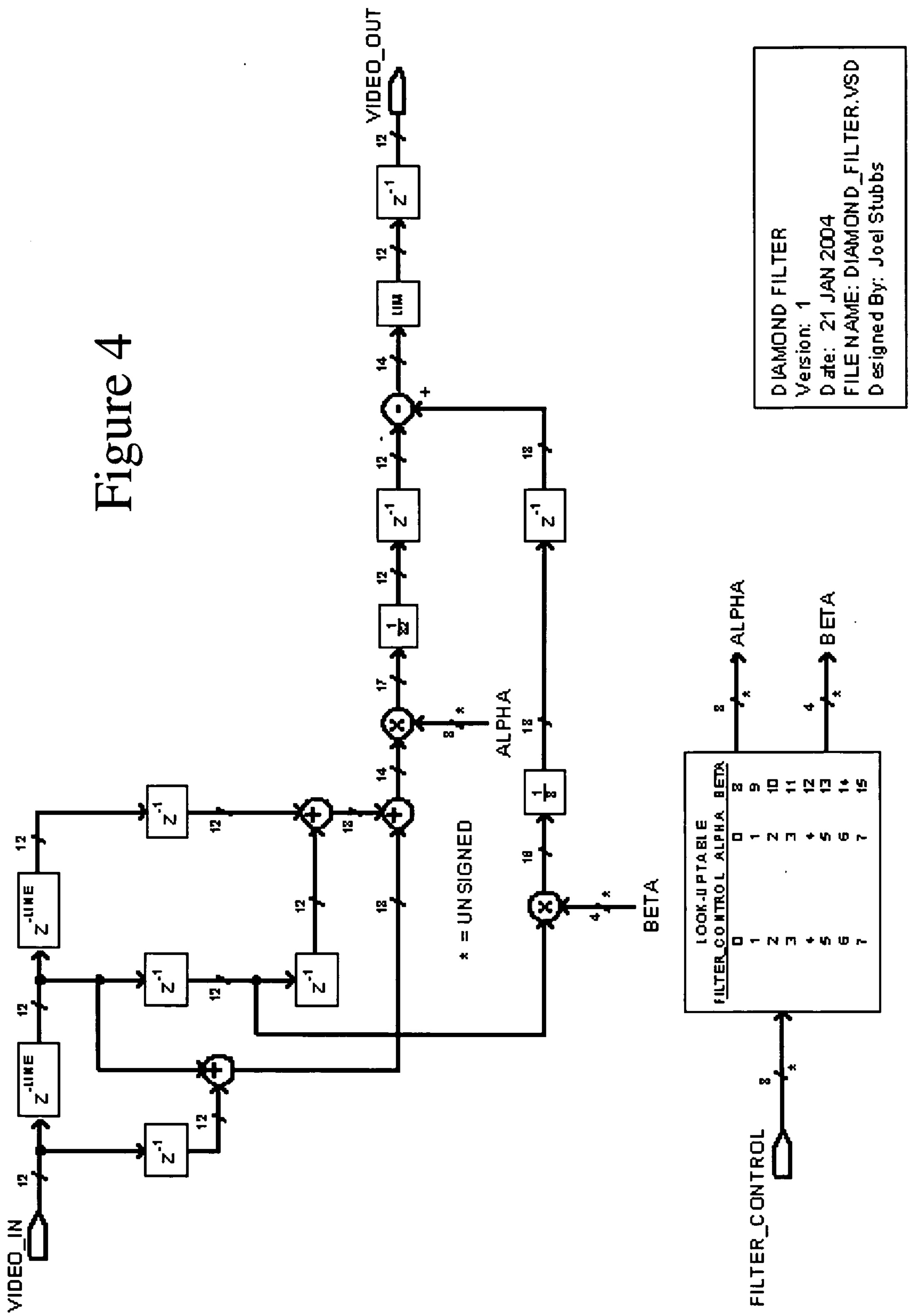
Figure 3B



Combined pixel set

Figure 3C

Figure 4


VIDEO_IN
VIDEO_OUT
FILTER_CONTROL
ALPHA
BETA
LIM
* = UNSIGNED
LOOK-UP TABLE
FILTER_CONTROL ALPHA BETA
0 0 8
1 1 9
2 2 10
3 3 11
4 4 12
5 5 13
6 6 14
7 7 15
DIAMOND FILTER
Version: 1
Date: 21 JAN 2004
FILE NAME: DIAMOND_FILTER.VSD
Designed By: Joel Stubbs